

EXPANDED COAL PRODUCTION  
ENVIRONMENTAL IMPLICATIONS AND POLICY CONSIDERATIONS

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INTRODUCTION

Coal is considered one of the most valuable natural resources in the United States. Coal production in 1976 amounted to 665 million tons, and at such rate of production it could last for 300 years or more.

The earliest record of production in the U.S. was in 1820 when 3,000 tons of coal were produced. By comparison, total coal production in 1976 was 665 million tons, about 56% of which were produced by surface mining methods (Figure 1). During the period from 1939 to 1969, coal production from underground mines declined by about 3% from 357 million tons to 347 million tons, whereas coal from surface mines increased by 413%, from 38 million tons in 1939 to 195 million tons in 1969.

The electric utilities are the major users of coal in the U.S. The U.S. Bureau of Mines (1) reports that 390 million tons of coal (about 65% of the total production) were burned in electric power plants in 1974 and the trend for coal use by utilities is projected to increase to 800 million tons in 1985 (2).

In April 1977, President Carter announced his National Energy Plan with specific proposals aimed at solving the nation's energy problems. In order to reduce U.S. dependence on oil imports, one of the major proposals of the National Energy Plan is to increase coal production to 1,265 million tons in 1985, an increase of 90% over 1976 level. Long-range plans of the coal industry, without the new plan, call for an increase in coal production to about 1,040 million tons by 1985, about two-thirds of which would be mined in the East and about one-third in the West (Figure 2). Clearly, the major expansion in production will occur in the West, increasing by fourfold from 92 million tons in 1974 to about 380 million tons in 1985. The National Energy Plan, on the other hand, proposes to reduce the share of total production to be mined in the West and increase the share that will be mined in the East. In both plans, however, new developments for meeting production goals will be concentrated in surface mining operations, amounting to over 75% of the new facilities (3).

Coal mining and coal conversion have significant impacts on the environment of a region, some of them are irreversible and permanent. They include adverse impacts on: water quality and quantity, topography, soil erosion, surface subsidence, land use, landscape aesthetics, air pollution and associated health effects, as well as social and economic impacts. Some of these impacts are not presently regulated.

ENVIRONMENTAL IMPACTS OF SURFACE COAL MINING

Water Quality

Deterioration of water quality results mainly from acid mine drainage which affects water quality by lowering pH, increasing total

dissolved solids and adding undesirable amounts of heavy metals and sulfates (4, 5). Table 1 lists some examples of acid mine drainage from surface coal mines in four regions.

Table 1  
Examples of Mine Drainage  
From Surface Coal Mines (After: Hill (6))

	Southwestern Indiana	Western Pennsylvania	Southeastern Illinois	Northern West Virginia
pH	5.7	3.2	2.7	3.0
Acidity, mg/l	0	152	1,620	870
Alkalinity, mg/l	170	0	0	0
Hardness, mg/l	1,780	-	-	-
Iron, mg/l	0.4	9.4	130	75
Sulfate, mg/l	850	499	-	1,742
Chloride, mg/l	7	-	-	-
Manganese, mg/l	7.8	-	-	-
Calcium, mg/l	328	-	-	-
Aluminum, mg/l	-	-	-	60

Pollution by acid mine drainage increases the cost of water treatment, destroys aquatic life (7), inhibits the use of waterways for recreation and decreases aesthetic values. The major problems of acid mine drainage occur in the anthracite and bituminous coal regions in Appalachia. In 1964, the U.S. Fish and Wildlife Service reported that acid mine drainage adversely affected 5,890 miles of streams and 14,967 acres of impoundments in 20 states (7). Of the total affected waters, coal mining operations accounted for 97% of the AMD pollution reported for streams and 93% of that reported for impoundments. In 1970, more than 12,000 miles of streams in the U.S. were significantly degraded by mining related pollution (8). Of these, 10,516 miles or approximately 88% were located in Appalachia.

Western coal, generally, contains little pyrite and the stream waters and soils, in the West, are often highly alkaline resulting in that acid mine drainage is not as great a problem as it is in the East. However, high dissolved solids content and heavy metals remain a problem resulting in adverse impacts on the beneficial use of water in the West, specially on agriculture. In addition, shales overlying Paleocene coals in the Northern Great Plains may contain between 300-500 ppm total nitrogen which could cause a buildup of nitrate in surface and ground water around refuse piles (9).

Another aspect of stream pollution involves increased sediment loads resulting from destruction of vegetative covers, steep slopes, disruption of soil structure and compaction which increases erosion potential, and from refuse and coal storage piles. Sediment yields of as much as 1,000 times their former levels have been reported from surface mined regions in Kentucky (10).

Increased coal production, as proposed in the National Energy Plan, is expected to result in an increase of 107% for total dissolved solids in the nation's waters by the year 2000 over their 1975 levels (11). Runoff from coal mining operations is projected to account for 30% of dissolved solids releases in 2000. In the semi-arid West, total dissolved solids from coal extraction, cleaning and conversion are expected to increase fivefold in the same 25-year period.

## Water Quantity

Surface streams are affected through decreased surface runoff through diversions and seepage. In the semi-arid West, most streams are intermittent or have very little flow during dry seasons. Accordingly, there is little stream flow available for dilution of mine drainage. Heavy sediment loads during periods of high flow can have adverse effects on important aquifers downstream from a stripping operation. Fine silt and clay from refuse piles can result in surface sealing and reduction of the infiltration capacity of the soils.

Surface mining operations may disrupt groundwater flow patterns as well as natural recharge areas. In some cases a coal seam acts as an aquifer that can be drained by the mining activity (12). Accordingly, groundwater supplies above and below the cut may be depleted temporarily or permanently (Figure 3). In the West, alluvial aquifers are an important source for irrigation water. In addition, shallow alluvial aquifers serve to buffer seasonal fluctuations in surface runoff and reduce flood peaks through bank storage.

Mine location relative to aquifers could play a major role in minimizing the impacts of a surface mine on ground water resources (13). Figure 4 shows that the mine located at the left will cause both local and regional effects on the water resource while locating the mine at the outcrop of an aquifer (mine location at the right) will have only local impacts on ground water.

In addition to the effects on surface and ground water resources, surface mining of western coal would also intensify existing demand and competition for scarce water resources. Potential problems include water depletion for surface reclamation and for rapid increase in population.

## Topography

Topography is modified by the elimination of old landforms and the creation of new ones as well as by increased slope angles. Moisture-catching depressions and pits increase the potential of acid mine drainage production in the East and may cause surface accumulation of salt in the West. It should also be mentioned that actions which change the topography of an area also influence the surface and subsurface drainage patterns of that area. In the Wilkes-Barre area in the Northern Anthracite Field of northeastern Pennsylvania, surface mining along the ridges on both sides of the Wyoming Valley with its attendant unreclaimed pits that continually collect water from precipitation and from upward movement of ground water have resulted in a rise in the ground water table in the valley floor causing basement flooding in many homes.

## Air Pollution

Air pollution as a result of surface mining is primarily in the form of airborne particulate matter from silt ponds and refuse banks, and gases from culm (refuse) bank fires. The most toxic gases are carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), hydrogen sulfide (H<sub>2</sub>S), sulfur dioxide (SO<sub>2</sub>), and ammonia (14). These gases in addition to smoke and minute dust particles have in many instances proven fatal to vegetation, a health hazard to humans, and caused deterioration of surrounding buildings and structures.

In 1968, the U.S. Bureau of Mines reported 292 burning coal refuse banks throughout the United States covering over 3,200 acres (14). In comparison, 495 coal refuse banks were burning in 1963, in 15 out of the 26 coal-producing states.

#### Social and Economic Impacts

The influx of large numbers of people in a relatively short period of time into sparsely populated areas, attracted by mining activities and energy-related developments, results in significant social and economic impacts. The influx of money and jobs during the height of the mining operations and related activities brings along an economic boom and high inflation that only turns into a bust when the operation is completed. Many of the poverty stricken areas of Appalachia are living examples of such process. Gillette and Rock Springs, Wyoming, are good examples of present-day boom towns. The last examples are cause for concern when potential massive development of western coal is considered. The Northern Great Plains is a vast, rural, sparsely-settled region. The population of Campbell County, Wyoming, is expected to increase sixfold to 70,100 by the year 2000 if development proceeds as projected (15). Most of this growth will occur in Gillette which can be expected to reach a population of 65,000 by the year 2000 (Figure 5). The competition for labor by coal-related industry in this area will have a direct effect on present industry. Agriculture is the present economic base of much of the Northern Great Plains.

#### ENVIRONMENTAL IMPACTS OF UNDERGROUND COAL MINING

##### Acid Mine Drainage

Abandoned underground coal mines and abandoned mine waste disposal sites contribute a large portion of the acid mine discharge. Of the sources of acid mine drainage located and described in Appalachia by the Federal Water Pollution Control Administration between 1964 and 1968, abandoned underground coal mines were found to contribute 52% of the total acid discharge to streams (8). In 1973, acid discharge from abandoned eastern underground coal mines totaled more than 5 million lb./day which was the largest single source of AMD in the U.S. (16).

The large volume of AMD from abandoned underground mines is attributed to fracturing or general subsidence of overlying strata resulting in increased vertical permeability and flow of large volumes of water into the mine void (Figure 6).

Control of acid mine drainage from future underground mining operations could be accomplished through proper selection of mining techniques, water handling and mine sealing. Downdip mining involves the location of mine openings at a high elevation in the seam while development proceeds downdip. Flooding of the mine is automatic after completion of the mining operation thus isolating sulfide minerals in the mine, minimizing oxidation and resulting in better quality discharges than has occurred from the abandoned mines that were developed updip (16). Longwall mining should also be an effective method of improving quality of mine drainage. Controlled fracturing and caving of the roof behind the advancing face reduces void space and inhibits the oxidation of sulfides in the mine.

## Subsidence

The two principal underground methods of coal mining in the U.S. are room and pillar and longwall. In room and pillar mining operations, failure of one or more roof supports and failure due to overburden loading on broad roof spans between supporting columns result in collapse of the overlying strata and surface subsidence. The extent of the subsidence zone and the nature of subsidence vary from area to area and depend mainly on the type of mining, width of the mined-out area, thickness of the coal seam, and the depth and characteristics of the overburden.

Surface subsidence may result in excessive damage in highly developed urban areas. Good examples exist in northeastern and in western Pennsylvania. Other land uses are usually less severely affected. In general, lateral stresses result in more severe damage than vertical movement, and they are most intense at the periphery of the subsidence area (17).

## Solid Waste (Refuse Banks)

There are between 3,000 and 5,000 refuse banks, containing over three billion tons of refuse, in the eastern coal fields alone. Production of solid waste from all coal mining in 1973 totaled about 110 million tons. A study by the Bureau of Mines estimates that between 1930 and 1971, almost 166,000 acres of land were utilized for disposal of underground mining and processing wastes (18). Of the total, only 20,000 acres were reclaimed.

Refuse banks are a potential source of air and water pollution. When ignited, they provide noxious and lethal gases as mentioned before. Water pollution results from sediment and acid mine drainage.

Underground disposal of coal mine waste is a viable alternative to their disposal on the surface and limits land use impacts. However, experience in this field has been limited in the U.S.

Increased coal production implies increased solid waste that is neither utilized at present nor disposed back underground. The Bureau of Mines estimates that about 10 acres of land are utilized for disposal of coal mine and preparation plant wastes for every million tons of coal produced (17). It is estimated that coal mining wastes will nearly double between 1975 and 1985 (11). However, under the proposed National Energy Plan, they will nearly triple between 1975 and 2000. About three-fourths of the wastes are expected to occur in the eastern regions.

## Abandoned Mine Fires

U.S. Bureau of Mines figures show that as of January 1973, there were 59 uncontrolled abandoned mine fires in Appalachia and about 185 uncontrolled fires in the western regions. Abandoned underground mine fires have severe land use implications. They result in surface subsidence while the release of toxic gases is a hazard to human health and to vegetation.

## ENVIRONMENTAL IMPACTS OF COAL TRANSPORTATION

The bulk of coal produced in the U.S. is presently being transported mainly by rail (65%), barges (11%), trucks (13%) and Great

Lakes colliers (3%). In addition, transportation of coal by slurry pipelines has been proposed as a method for moving large tonnage of western coal over great distances.

Rail is the primary method for coal transportation in the U.S. All rail movements totaled over 290 million tons in 1973, a 41% increase since 1962 (18). The most significant environmental impacts associated with railroad traffic include: noise, air pollution and congestion. Increased coal production and transportation will only intensify these impacts, particularly congestion problems in western towns.

The channelization of streams, construction of canals and dredging and disposal of dredged spoils in connection with construction and maintenance of waterways for barges have adverse impacts on water quality and in many cases has resulted in the destruction of fresh or coastal wetlands.

The major environmental impacts of trucks are air pollution, noise, highway safety and congestion. In addition, increased truck traffic to accommodate the planned doubling in coal production might necessitate new construction of highways with their attendant environmental impacts.

The major environmental impacts of coal slurry pipelines are almost entirely related to their use of water. They involve water depletion and water quality degradation. Proposed slurry pipelines are expected to obtain their water from ground water sources. Since one ton of water is needed to move one ton of coal, massive amounts of water, in a region that is normally short in water supply, are needed to transport over 100 million tons of coal a year. Without adequate ground water management plans, the construction of slurry pipelines in the West could result in significant ground water problems as well as water quantity and quality problems for surface streams connected with the disturbed aquifers.

#### ENVIRONMENTAL IMPACTS OF COAL CONVERSION

Air pollution is the most serious environmental problem associated with the conventional burning of coal. In 1974, 390 million tons of coal (about 65% of the total production) were burned by electric utilities for power generation. By 1985, this figure is projected to double to about 800 million tons. At present, nearly two-thirds of the sulfur oxides and one-third of the particulate matter emitted into the atmosphere are from burning coal for electric power generation. In addition, significant amounts of nitrogen oxides, carbon monoxide and hydrocarbons are also emitted in the coal burning process. All of these pollutants are known to have adverse impacts on human health. Carbon dioxide is also released in the coal combustion process. There is mounting concern that carbon dioxide buildup in the atmosphere may result in a "greenhouse" effect causing global climatic changes. It is important that knowledge of the long-term effects of coal development be improved before irreversible effects are encountered.

Gasification and liquefaction of coal may offer major air quality advantages for currently regulated pollutants. However, they present uncertain, potentially serious hazards for pollutants that are not yet regulated (19), particularly organic compounds that are proven carcinogens.

Major increases in electricity generation from conventional coal combustion could have great adverse air quality consequences in the absence of improved combustion and pollution control technologies. In this regard, the National Energy Plan proposes that best available control technology (BACT) be required on all new coal-burning facilities. The same provision has been included in the Clean Air Act Amendments of 1977. Yet, it is projected that sulfur oxides and nitrogen oxides will be higher in 1985 and 2000 than in 1975 (11). In the year 2000, sulfur oxides are projected to be about 12% higher and nitrogen oxides about 61% higher than in 1975. If SO<sub>x</sub> and NO<sub>x</sub> are to be reduced, continued improvements in BACT will be required. In addition, with planned and proposed increase in coal utilization, increasing amounts of sludges and spent ashes from coal combustion facilities may present a solid waste disposal problem and these wastes may cause a significant potential leachate problem (11). It is projected that in 2000, non-combustible solid wastes from coal burning would increase to 2.7 times the 1975 level and sludges would increase to 8.5 times the 1975 levels (11).

#### POLICY CONSIDERATIONS

From an environmental standpoint, coal is clearly the dirtiest of all fossil fuels. Severe environmental problems are associated with every phase of the fuel cycle. Table 2 presents a summary of key environmental issues associated with coal mining, preparation, transportation and conventional combustion.

Table 2  
KEY ENVIRONMENTAL ISSUES AND REGIONAL CONCERNS  
(Federal Regions: 3=Middle Atlantic, 4=South Atlantic, 5=Midwest, 6=Southwest, 8=North Central)

Energy Process	Key Environmental Issues	Regions of Concern
Coal Mining	Stabilization/disposal of underground mining wastes	Regions 3,4,5
	Reclamation of strip-mined land	Water scarce Regions 6,8, parts of 4
	Acid mine drainage	Regions 3,4,5
	Alkaline mine drainage	Primarily Region 8
	Occupational health and safety - underground mining - surface mining	Regions 3,4,5 Regions 4,6,8
Coal Beneficiation	Suspended solid runoff (final EPA regulations may be less stringent than those assumed in study)	Regions 3,4,5,8
Coal Transportation	Occupational and public health and safety issues (rail accidents)	Primarily Regions 3,4, 5
	Particulate emissions	Highest in Region 5
Conventional Coal Combustion -Elec. Utilities -Indust. Boilers	Ash and sludge disposal SO <sub>x</sub> emissions	Urban areas Reg. 5 (highest), Reg. 6 (largest increases)

The proposed National Energy Plan, while it "intends to achieve its energy goals without endangering the public health or degrading the environment," its only specific proposals for environmental protection concern strip mining reclamation and air pollutants for which present criteria exist. However, conventional coal combustion and conversion to synthetic gaseous and liquid fuels may result in a much greater range of social and environmental impacts than those presently regulated. In the short term, there can be some temporary trade-offs between coal development and environmental protection. However, in the process of solving this nation's energy problems, we must seek to avoid irreversible and permanent damage to the natural and human environment.

The environmental impacts of increased coal production and utilization, particularly with present technology, are clearly unacceptable. In order to minimize environmental damages more emphasis must be placed upon energy conservation and slower energy growth. While the proposed National Energy Plan represents a step forward in that direction, it could have gone a good deal farther. Energy conservation is more expedient than developing new sources and can be accomplished with less expense than building new capacity. Conservation will minimize the need for more expensive and environmentally harmful supply options and will help in providing time for developing acceptable supply sources. The most conspicuous, benign, and inexhaustible source of alternative energy is solar energy. However, present levels of solar research funding and efforts to disseminate it in the marketplace are inadequate.

Unless we change our emphasis away from centralized fossil and nuclear generation facilities towards the more environmentally benign technologies, levels of many pollutants will increase sharply in the next two decades which may pose great hazards to human health and food production.

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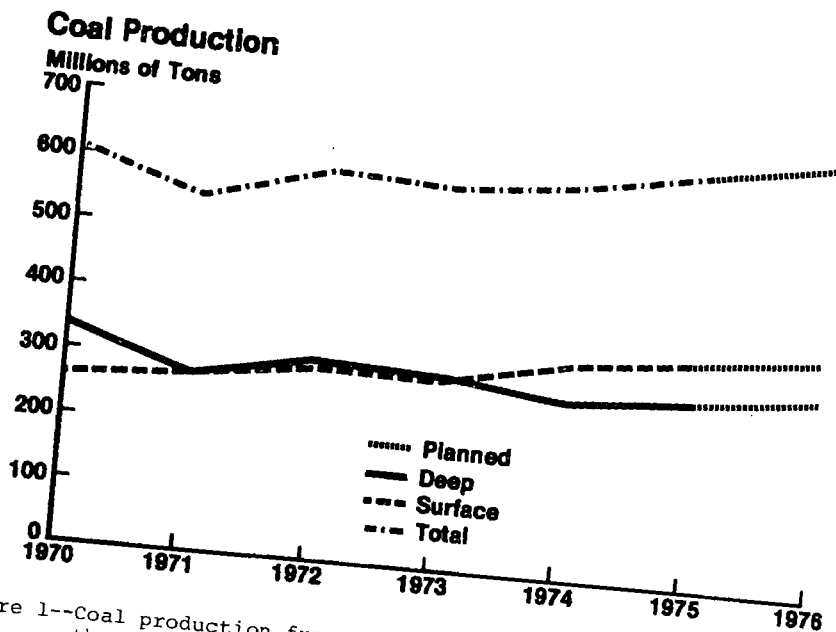


Figure 1--Coal production from underground and surface mines, in the U.S., 1970-1975 (20).

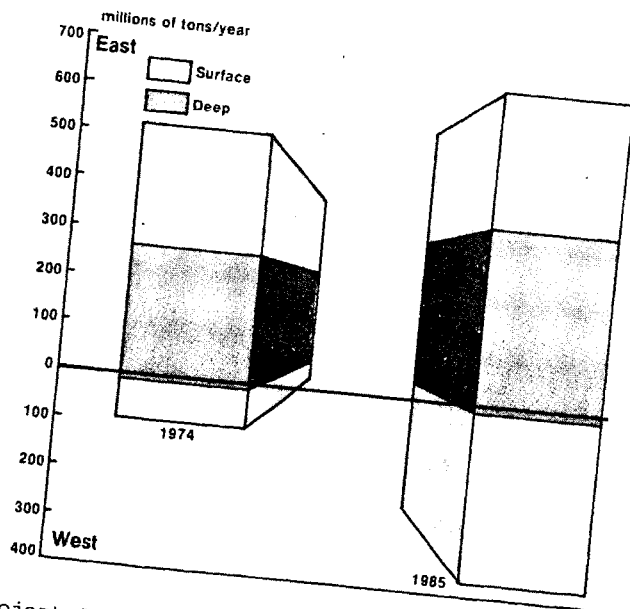


Figure 2--Projected coal production in the U.S., by region, in 1985 (21).

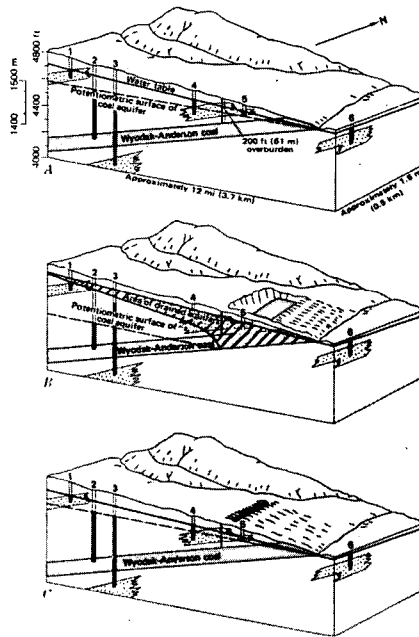


Figure 3--Potential effects of surface mining on shallow aquifers (12).  
A: before mining, B: after mining, C: after reclamation.

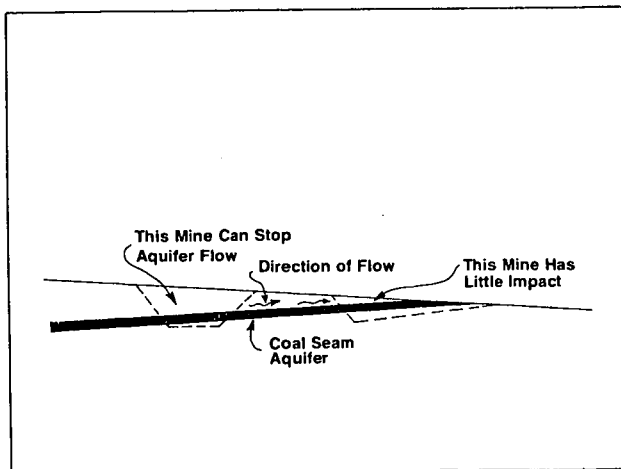


Figure 4--Impact of mine location on shallow aquifers (13).

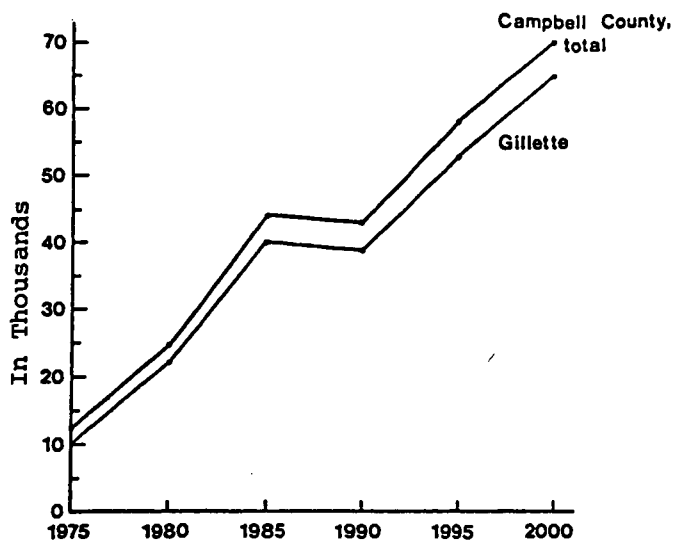


Figure 5--Population estimates for Campbell County and Gillette, Wyoming, 1975-2000 (15).

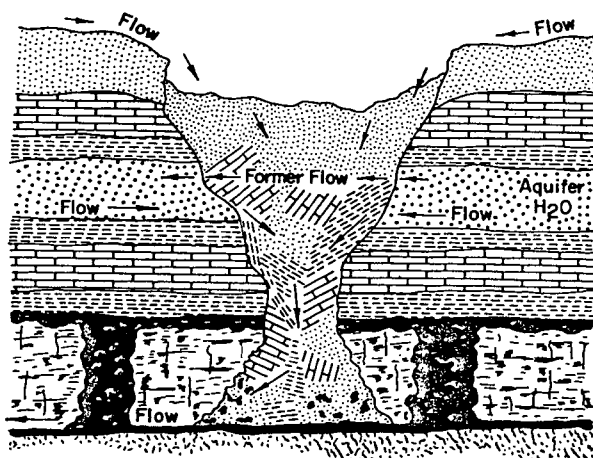


Figure 6--Infiltration of water through collapsed area (16).